Homework 2 prepared for Prof. M. Khalid Jawed teaching MAE 263F in Fall 2025

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I. Code Description

Most of the code was used from Homework 1 with some modifications. Primarily, an additional script was created to generate the node, stretch spring, and bending spring files. The core desire was to isolate the physical parameters of the problem into initSpringNetwork such that running the Homework2 python file would solve based on the data in the text files. This means that the mass per node and the spring stiffness were also stored in the text files.

The remaining changes from Homework 1 were to implement code for the addition of bending springs, as well as modifying the getExternalForce function to only apply the point load without gravity.

II. Task

A. *Plot the maximum vertical displacement over time.*

Based on the plot seen in Figure 1 the beam slightly overshoots a stable value and immediately returns to a steady value. This can be explained in part by the numerical damping present in the implicit Newton-Raphson solver. Oscillations would be expected as only conservative forces are present in the system.

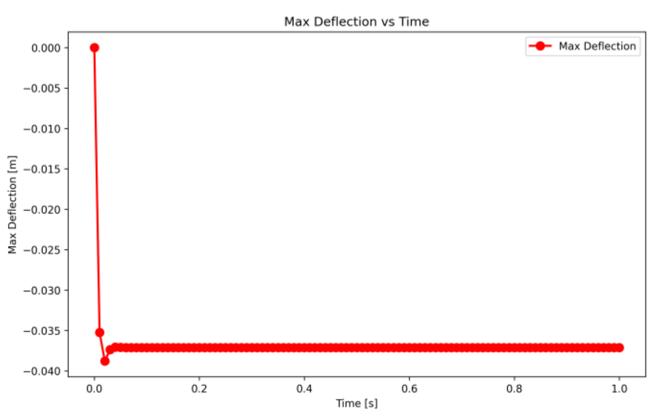

Figure 1: Max Deflection of simulated beam over time with static point load of 2000 N.

Figure 2 shows the beam at the end of the simulation, when it has reached a steady position, with the expected deflection and max deflection locations annotated. The expected values were determined using Euler-Bernoulli Beam Theory in Equation 1 for the maximum deflection and Equation 2 for the location.

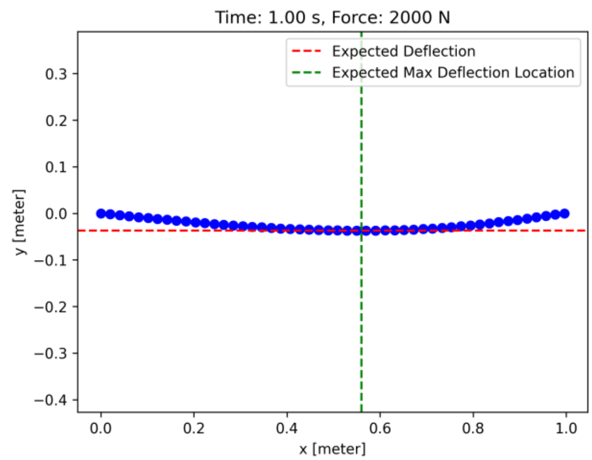

Figure 2: Simulated Beam with 2000 N point load, annotated with predicted max deflection and corresponding location.

$$y_{max} = \frac{Pc(L^2 - c^2)^{1.5}}{9\sqrt{3}EIL},\ c < \frac{L}{2} \tag{1}$$

$$x = \sqrt{\frac{L^2 - c^2}{3}} \tag{2}$$

B. *Simulation benefits over Euler-Bernoulli Beam Theory*

The simulation of the beam becomes more accurate than the Euler-Bernoulli equation when the load creates a large deflection. The root of this error is that the theory assumes that planes perpendicular to the axis of the beam will be parallel to one another, which is only valid under small deflections. The simulation is not limited by this. Figure 3 shows the expected deflections from the beam by the Euler-Bernoulli Beam Theory and the deflection from the simulation.

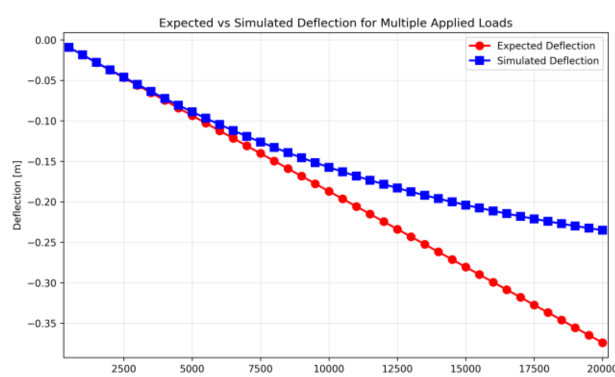

Figure 3: Simulated and Expected Deflections of Various Point Load Magnitudes.

Figure 4 shows the percentage error between the two results. The point at which the curve fit produced zero error is at 2081 N of force.

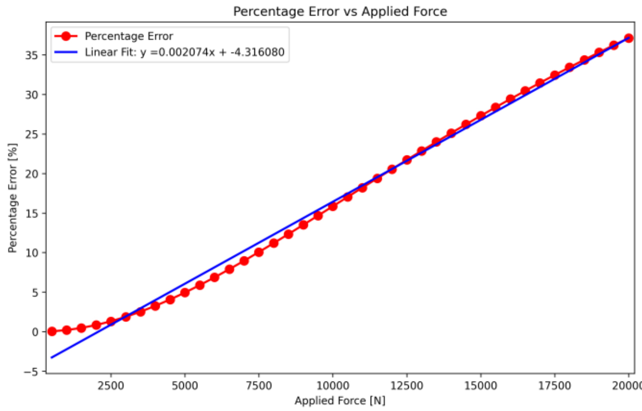

Figure 4: Percentage Error between the Simulated and Expected Deflection.